Industrial Engineering as a Career Choice at the University of Johannesburg.

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Internationally the demand for industrial engineers is growing, due to the economic downturn as well as constraints on natural resources. Yet, at the University of Johannesburg, the majority of students who seek admittance to the engineering faculty do not choose industrial engineering as their first choice. A quantitative study was done by surveying industrial engineering students in the first and second year, to determine the number of engineering students at UJ whose first choice was industrial engineering. In addition the satisfaction with the course of those students who did not choose it originally was determined. We investigated the impact of open days and engineering weeks, as arranged by the University, on pupils' choice of industrial engineering? The study found that a large portion of students did not choose industrial engineering as their first choice and it seems to be due to a total lack of knowledge with regard to industrial engineering. The perceptions of school pupils of engineering need to be changed and issues with the current standard of high school mathematics need to be explored further. The question to ask is: How can we improve the marketing of industrial engineering as a career.

Introduction

The demand for industrial engineers is growing internationally. This is due in part to the economic downturn as well as constraints on natural resources. On the South African scarce skills list, industrial and production engineers are listed eighth (2014). Industrial engineers have a key role to play in economic growth by helping companies to become more competitive and productive. By increasing productivity salaries can be increased without inflation increasing and in this way quality of life can be improved.

The definition of Industrial Engineering according to the South African Institute of industrial Engineers (SAIIE) is "the integration of resources and processes into cohesive strategies, structures and systems for the effective and efficient production of quality goods and services" (SAIIE, 2016). According to the business dictionary the definition of industrial Engineering is "the discipline of utilizing and coordinating humans, machines and materials to attain a desired output rate with the optimum utilization of energy knowledge, money and time. It employs certain techniques such as floor layouts, personnel organization, time standards, wage rates, (incentive payment plans) to control the quantity and quality of goods and services produced." (Business Dictionary, 2016)

It is well publicised that there are serious problems with service delivery in the public sector specifically with regard to the functioning of municipalities, hospitals and clinics. Much research has been done on the role of industrial engineering in the health care sector. Industrial engineering techniques can be applied to improve the balance between resources and service.

Yet, at the University of Johannesburg, the majority of students who seek admittance to the engineering faculty do not choose industrial engineering as their first choice. Students end up

in industrial engineering because they did not gain admittance to the engineering field of their choice and as a last resort they apply to Industrial Engineering provided there are still vacancies left.

No studies were found that addressed attraction to industrial engineering specifically which justifies further research in this regard.

Objectives

Firstly it was important to determine the percentage of engineering students at the University of Johannesburg whose first choice was industrial engineering. Secondly, the satisfaction with the course of those students who did not initially choose industrial engineering was established. The third objective was to improve the marketing of industrial engineering to prospective students in South Africa.

Literature review

Science and Engineering occupations are critical to global competitiveness and for an economy to prosper. Engineering is linked to innovation, jobs and wealth creation. Previous studies have shown that engineering is often seen as a strong profession but few high school pupils have an understanding of the engineering profession (Education and Culture, 2012). In South Africa as in most countries, there is a shortage of engineers in general, and industrial engineers specifically which may be a factor in the slowing of the economy.

Research has been conducted internationally to determine the factors that motivate students to study engineering and how to attract more students to the field (Osborne, Simon, and Collins, 2010). The "educate to innovate" project in the USA was initiated by President Obama (Whitehouse, 2016). The goal of this project is to move American students from the middle to the top of the pack in science and mathematical achievement (Kyoung, Lattuca, and Alcott, 2017). The USA has approached this initiative by: Partnering with CEO's from over a 100 companies in order to expand proven science, technology, engineering and mathematics (STEM) programs to sites across America. They also created a blueprint for the private sector to develop and invest in STEM programs. Companies that are the largest employers in communities advocate STEM reform in those communities. Their goal is to train 100 000 new and effective STEM teachers in the next ten years. They have raised funds privately and motivated for Congress to fund the rest. They have engaged current talented STEM teachers to assist in this endeavour. They are publicly demonstrating and increasing their investment in STEM as demonstrated in an annual White House Science Fair and lastly they are broadening participation including women, girls and minorities to ensure a more diverse STEM talent pool.

In Europe an extensive study "The Attract project –Enhance the Attractiveness of Studies in Science and Technology" was conducted. This research investigated the perception of engineering in eight European countries. Four specific areas this study focused on were the attractiveness of being an engineer; barriers; attraction and retention (Education and Culture, 2012). It was found that engineering is perceived as a difficult study with a limited outcome which was one of the main reasons for decreased interest in the field. As a career it is seen as a high income and exciting job with high status.

Even though the South African environment is very different from the European and American environment much insight can be gained from these studies as to how to attract more students to engineering in general. Some of these findings and interventions could be applicable to South Africa. Studies have been done to determine factors that motivate South

African students to study engineering. (Jawitz and Case, 1998). Some of these factors are: contact with engineering career, school subjects, socialisers, manual activities, mental activities, career rewards, challenge, variety, and social identity, belief in self, salary and status (Reed and Case, 2003).

One of the common finding in literature is that more women need to be attracted to engineering. The absence of women in the labour market has been associated with lower economic growth and development (Elborgh-Woytek, et al., 2013). The discrepancy between the number of men and women in engineering fields is not because of a mismatch of skills and the requirements for becoming a successful engineer but rather of perceptions about engineering (Marra & Bogue, 2004). Fewer than five percent of female pupils in the Organisation for Economic Co-operation and Development (OECD) countries consider following a career in engineering and computing whereas eighteen percent of male pupils do (OECD, 2012). There seems to be a biased self-concept in female pupils with regard to science (Sikora and Pokropek, 2012). More female students tend to enrol in Industrial Engineering than any other of the engineering disciplines, often because of social reasons (Brawner et al. 2012). It has been recommended that to increase the number of female students in engineering, a way should be found to make physical science a more attractive and pleasant experience. A study by Jawitz et al (Jawitz, Case , and Tshabalala, 2000) showed that engineering was only considered by females who enjoyed physical sciences. (Jarwitz, Case , and Tshabalala, 2000).

It seems that, the South African schooling system tends to reinforce the social and economic marginalisation of the poorest and most vulnerable people (Maree, 2010). Bloch provides the following figures "A small cohort of 20% of South African schools, half of which are former Model C (currently Section 21) schools and the other half well-performing black schools, delivers the vast majority of the country' s eventual graduates" (Bloch, 2009). Most of these schools are quintile 5 schools. According to Vinjevoldt (2009) "Mathematics at school is not studied in-depth, consequently there are gaps in learners' understanding of the subject when they arrive at university". Several studies indicate that preparation of mathematics has a direct impact on attraction and retention of engineering students (Hall, et al., 2015). Problems within the schooling system may have an influence on the potential number of applicants to engineering.

There is still a disparity regarding race in industrial engineering in South Africa (Schutte, Kennon, & Bam, 2016). It seems that very few black, coloured and Indian students choose to follow the academic programme for industrial engineering. However there are large numbers of these following the technical programmes.

Methodology

This case study attempts to determine the reasons why students at the University of Johannesburg did not make industrial engineering their first choice. In addition student satisfaction with the course was evaluated as well as methods to attract more students to industrial engineering. A quantitative study was done by surveying National Diploma (NDip) industrial engineering students in their first year, second year and at Bachelor of Technology (BTech) level at the University of Johannesburg.

The purpose of the questionnaire was to determine the percentage of industrial engineering students who chose industrial engineering as their first choice. The questionnaire addressed the following issues: Student's awareness of industrial engineering prior to commencing with the course. Students were asked if industrial engineering was not their first choice what their first choice was (see appendix 1). Questions about motivational factors that played a role in

choosing industrial engineering were asked. The questionnaire also addressed whether students were satisfied being allocated to industrial engineering (questions 16 to 19 in appendix 1). The students were asked whether laboratories and practical's gave the students an understanding of what industrial engineering entailed. In addition we investigated the impact of career guidance prior to the commencement of their studies, in the form of open days and engineering weeks. Open ended questions in this survey asked students the reason for not choosing industrial engineering and why they agreed or disagreed with the statement that they were now in the right field of engineering. For the close-ended questions a five point Likert-scale was used. Informal interviews were conducted with ten students who had indicated that industrial engineering was not their first choice. These students were asked the reason for not choosing industrial engineering and what their first choice had been. The factors that made industrial engineering enjoyable were determined. They were asked if they had their current knowledge at registration whether it would have influenced their choice. They were questioned on whether they regretted studying industrial engineering. SPSS was used to analyse the data. Of the students surveyed a total of 190 students questionnaires were analysed.

Findings

From the questionnaires analysed, 59% of students indicated that industrial engineering was not their first choice. Only 37.4 % indicated that they knew what industrial engineering was before they started. Responding to the question of whether or not students were of the opinion that they were now studying the right field of engineering, 77% of the group agreed. When asked whether they enjoyed studying industrial engineering 85% of the group agreed with this statement. Only 58% of students found industrial engineering studies challenging. Of this group 88% indicated that they believed industrial engineering was a desirable career for the future. Only 22% of the group ever attended an engineering week and of this group 64% of the students indicated that the engineering week changed their view of industrial engineering and 71% indicated that it was a positive change. A larger group 56% attended open days at a University but in this group only 34% stated that it had changed their view of industrial engineering.

In the informal interviews the students were asked why industrial engineering was not their first choice. According to the students a total lack of knowledge with regard to industrial engineering was the reason for not considering it as a career option. Most students knew about other engineering courses. All the students interviewed had chosen one of the other engineering fields as their first choice.

At the University of Johannesburg in the mechanical and industrial engineering department approximately 40% of our students come from quintile 1 and 2 schools (the poorest schools). As indicated these schools typically do not produce large numbers of graduates and often the mathematics preparation is not adequate.

Enrolments first time undergraduates	**Department**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**
Percentage of students from the lowest SA quintile schools (quintile 1 and 2)	MECHANICAL & INDUSTRIAL ENG TECH	43.9%	40.1%	50.0%	46.6%	36.8%	38%

Table1. The number of students from quintile 1 and 2 enrolled at the University of Johannesburg in Mechanical and Industrial Technology programmes

Enrolments first time undergraduates	**Department**	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**
Percentage of students from high performing schools (quintile 5)	MECHANICAL & INDUSTRIAL ENG TECH	15.3%	15.1%	17.9%	18.8%	18.1%	21.8%

Table 2. The number of students from the best performing schools (quintile 5) enrolled at the University of Johannesburg in Mechanical and Industrial Technology programmes.

Conclusion

Extensive research has been done on how to better attract students to engineering and by implication this can also be applied to industrial engineering. Suggestions have been made that the perception of school pupils towards engineering needs to change. From our study it was apparent that at the University of Johannesburg most students who study industrial engineering had no idea what the course entailed when enrolling.

There are problems in South Africa with regard to our education system especially high school mathematics (Wolmarans, et al. 2010). These factors have a significant impact on preparing possible candidates for successful completion of their engineering studies. There is a need for effective STEM teachers. Potentially this would increase the number of pupils interested in engineering.

It appears that at the University of Johannesburg most industrial engineering students did not choose industrial engineering as their first choice mainly because they has never heard of it. As they continue with the course the students do enjoy their course and consider themselves in the right field of engineering. A large percentage of our students come from quintile 1 and 2 schools (the poorest schools). It would seem that industrial engineering needs to be marketed more effectively to Black, Coloured and Indian learners for academic and technical industrial engineering qualifications.

At the University of Johannesburg, the industrial engineering department has an active student group. They call themselves DIEO (Department of Industrial Engineering Organisation)? Of the students surveyed 46% were members of DIEO. The leaders within DIEO have approached the department for funds to visit a number of high schools in order to inform high school pupils of the value of industrial engineering as a profession. They plan to target schools in and around the Johannesburg metropolitan area.

Engineering weeks have a greater impact on perception of industrial engineering than open days at Universities. However it may be difficult for students to attend these presentations due to economic reasons.

In order to attract more pupils to study engineering, universities should develop projects to expose pupils at all school going ages to the fact that engineering can be fun and interesting (Jawitz, Case , and Tshabalala, 2000). Institutions exist with a science focus such as Sci-Enza

and Sci-Bono and it is believed that lessons can be learned from these projects. Perhaps an engineering project can be developed to give "engineering specific" exposure to pupils.

There needs to be a focus to increase the number of STEM teachers. It makes sense to involve private companies to help develop STEM programmes in various communities.

Industrial engineers in industry should become involved by exposing industrial engineering to scholars?

It is recommended that industrial engineers become more involved in social upliftment projects especially at University level. Few industrial engineers are involved in public services (such as municipalities) and it is an area where significant impact can be made. Engineers can change the world and it is believed that more top performers would be drawn to the field of engineering and specifically more women will be interested if they were aware of the social impact industrial engineering can make. This will also assist in decolonising the curriculum as practical examples from South African environment can be used to illustrate engineering concepts.

Industrial engineering is a comprehensive field which includes an understanding of people, machines, processes, information technology and finances. There are many career opportunities for industrial engineers in both the manufacturing and service industry. The researchers are of the opinion that if pupils understand what industrial engineering entails, it would positively impact the intake and retention of students.

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Appendix 1

Industrial Engineering Questionnaire

With this questionnaire we are trying to determine what motivates students to study Industrial Engineering and whether they believe they made the right choice later on.
Mark with a X where applicable.

1. Gender

Male	Female

2. Age _____
3. What level are you busy studying

S1	S2	B-Tech

4. Was Industrial Engineering your first choice when you registered?

Yes	No

5. If yes in question 4 motivated you to choose it?

_____

6. If no in question 4 what was your first choice?

_____

7. Did a parent or family member have any influence on your choice?

Yes	No

8. If yes in question 8 how did they influence you?

_____

9. I understood what industrial engineering was when I started

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree

10. I am studying the right field of engineering

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree

11. If you agree or agree strongly in question 10 please state why.

_____

12. If you disagree or disagree strongly in question 10 please state why.

_____

13. Laboratories and practicals have given me a better understanding of what I will do in the field?

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree

14. If you agree or agree strongly in question 13 please state why

_____

15. If you disagree or disagree strongly in question 13 please state why.

_____

16. I find your studies challenging.

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree

17. I enjoy studying Industrial engineering.

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree

18. I believe industrial engineering is a great career for the future.

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree

19. I believe industrial engineering is a job like any other.

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree

20. Did you ever attend an engineering week?

Yes	No

21. If yes in question 20, you did attend, did it change your view of industrial engineering?

Yes	No

22. If yes in question 21, view changed, was the change of view

Very negative	negative	Somewhat	Very positive

		positive	

23. Did you ever attend an open day at a university?

Yes	No

24. If yes in question 23, you did attend, did it change your view of industrial engineering?

Yes	No

25. If yes in question 23, view changed, was the change of view

Very negative	negative	Somewhat positive	Very positive

26. Are you a member of DIEO?

Yes	No

27. I attend DIEO events?

Never	Rarely	Sometimes	Often	Always

28. When did you decide to pursue a career in engineering

_____

29. When did you decide to pursue a career in industrial engineering

_____